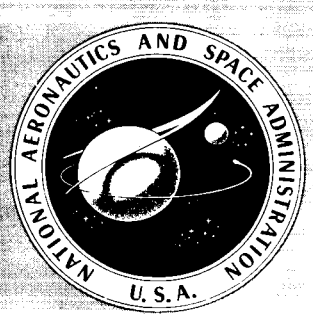
SUPPLEMENT TO
NASA SP-292
PANEL DISCUSSION

VEHICLE TECHNOLOGY FOR CIVIL AVIATION

The Seventies and Beyond

A conference held at
LANGLEY RESEARCH CENTER
Hampton, Virginia
November 2–4, 1971



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Prepared by Langley Research Center

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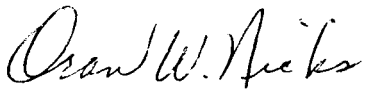
FOREWORD

This report is a transcript of a panel discussion held in conjunction with the NASA Conference on "Vehicle Technology for Civil Aviation – The Seventies and Beyond," November 2-4, 1971. The members on the panel were chosen as representative of several segments of the aviation community. Their participation on the panel was not rehearsed nor were there any formal preparations other than full-time attendance at the conference preceding the panel discussion. All of the members were well qualified, however, on the basis of their past aviation experiences and present key positions with industry and Government.

The panel discussion was taped during the session, and edited insignificantly by the panel members to ensure correctness. This report is therefore presented in the direct conversational style of the panel in order to retain its impromptu flavor and to ensure the best communication of the thoughts exchanged during the free discussion. It is felt that this document will effectively complement the formal presentations already published and distributed as NASA SP-292, "Vehicle Technology for Civil Aviation – The Seventies and Beyond," November 2-4, 1971.



Oran W. Nicks
Deputy Director
NASA Langley Research Center
Panel Moderator

Non-NASA Panel Discussion

Moderator: Oran W. Nicks – Deputy Director
NASA Langley Research Center

Members:

Brigadier General Gustav E. Lundquist
Associate Administrator for Engineering and Development
Federal Aviation Administration

Mr. Robert C. Collins
Vice President – Engineering
United Air Lines, Inc.

Mr. Richard E. Black
Director, Advanced Design
Douglas Aircraft Company
McDonnell Douglas Corporation

Mr. William H. Sens
Chief Engineer – Advanced Gas Turbine Engines
Pratt and Whitney Aircraft Division
United Aircraft Corporation

Mr. Louis Achitoff
Chief, Aviation Technical Services Division
The Port of New York Authority

Mr. Calvin F. Wilson, Jr.
Manager – Aerodynamics
Flight Test and Structures
Piper Aircraft Corporation

Moderator, Oran Nicks:

Well, gentlemen, we have come to the last session of our conference. This is to be an informal one; the people here have not rehearsed nor in any way prepared for this, other than to have worked in the fields they represent for many years and to have listened attentively to what's been said. I hope they will have some views and comments of their own, which will help put this all in perspective. In order to make it more interesting for you, I would like to introduce each of these gentlemen, with a little background information that I have been able to gather on them, and allow you to have your players in mind as they participate in this game.

General Gus Lundquist is Associate Administrator for Engineering and Development with the Federal Aviation Administration. He is responsible for the executive direction of all FAA engineering and development work and directs six major FAA organizations: The Systems Engineering Management Office, the National Airspace System Program Office, The Systems Research and Development Service, the Supersonic Transport Office, the V/STOL Special Projects Office, and the National Aviation Facilities Experimental Center. During World War II he flew combat missions in Europe. He was at Langley early in the war, doing dive tests with an F-51. After the war he went on to direct the X-1 test program and was one of the three test pilots for that airplane. In 1946 he won the Thompson Trophy, flying one of the early F-80's in the Cleveland Air Races. We are very pleased to have him here with us.

Mr. Robert C. Collins is Vice President of Engineering for United Air Lines. He is a native of the Pacific Northwest, where he graduated from Washington State some years ago. He went with United right out of college and pursued a commercial pilot's rating while working as an engineer at United's San Francisco maintenance base. He is qualified as captain in the DC-8, the B-720, 727, 737, and the Caravelle. He attended MIT as a Sloan Fellow and has served as manager of three different divisions of the United Air Lines Engineering Department before moving to the company's executive offices. In 1970 he went back to San Francisco as Assistant to the Vice President – Engineering, and became Vice President of Engineering in October of last year. We are proud to have such a representative of the airlines.

Mr. Richard Black is Director of Advanced Design for McDonnell Douglas Corporation. In this position, he is responsible for the development of new programs and is frequently called upon as the company spokesman in these areas. Prior to his assignment in Advanced Design, Dick served as chief engineer on the DC-8 and has been responsible for the stretched DC-8 and extended-range versions of this aircraft. Earlier than that, he was a project leader on the DC-9. He has been with Douglas for 21 years, starting as

a stress analyst, and has obviously progressed very rapidly during this period. We are proud to have him represent the major aircraft industries in engineering.

Mr. William H. Sens is Chief Engineer of Advanced Gas Turbine Engines for Pratt and Whitney Aircraft Division of United Aircraft Corporation. He began his career with United Aircraft as an analytical engineer and did tests on piston engines, advancing on into the jet age when it came along. In his position as Chief Engineer for Advanced Turbines, he is responsible for directing the new products development and advanced commercial and military program for air-breathing power plants. Prior to his service with United Aircraft, he worked for NACA for a while as an analytical engineer in Cleveland, and for a short period he worked as an experimental test engineer with the Wright Aeronautical Division of Curtiss Wright. We are proud to have him with us to represent the engine manufacturers in this game.

Mr. Louis Achitoff is Chief of the Aviation Technical Services Division of The Port of New York Authority. He joined the staff in 1958 as supervisor of aeronautical planning. Following his World War II experience as a Navy pilot, he worked for American Airlines and Colonial Airlines as an engineering pilot and operations engineer. As an engineering test pilot, he spent 7 years in the certification of new aircraft for the Civil Aeronautics Administration. In 1965, he received the Executive Director's Award of Achievement in recognition of his professional skills, vision, and persistence in promoting the development of a new type of glide-slope antenna for instrument landings at La Guardia Airport. He is a native of New York City with an Aeronautical Engineering degree and an airline transport pilot's rating. He knows what there is to know about the airport-airplane interface, as opposed to the airplane-airport interface. We are proud to have Lou represent that segment of the community.

Mr. Calvin F. Wilson, Jr., of the Piper Aircraft Corporation, is presently Manager of Aerodynamics, Flight Test, and Structures for Piper in Lock Haven, Pennsylvania. He has been associated with Piper for 13 years; prior to that he was with Fairchild and engaged in various activities including certification testing of the F-27. His responsibilities include the selection of aerodynamic and structural configurations, proof testing both on the ground and in flight, as well as the direction of analytical design aspects for Piper aircraft – ranging from trainers, agricultural, and twin executive aircraft with turbine power and pressurized cabins. We are proud to have him represent general aviation.

With that introduction, I would like to say just a word about how we are going to do this. The formalities are over; we are going to handle this on a first-name basis. I will start it with some questions that will allow each man to express himself in a few words. After I have asked a question and directed it at some particular individual, if somebody else on the panel feels motivated to talk, he's free to do so. After we have gone down the row here, I'd like to invite the panel members to discuss anything that comes to their

minds, and I would also like to open the questions to you people on the floor. We will be planning to finish this conference on time so we can meet our commitment to get you on your airplanes.

Starting, then, with Gus, I would like to ask him a question that concerns the Government role in helping to develop and apply the new aeronautical technologies that we see coming forward. In particular, I'd like to ask him if he has some ideas he could share with us on what kind of experiments and team organizations make sense for exercising the new STOL technologies that will involve not only the airframe and airline industries, but the specialists from HEW, the airports, HUD, and whoever else ought to be involved.

General Lundquist:

Well, that's quite a question, Oran. First of all, on the Government role in technology – I think everyone in this room would agree that with the development of any new aircraft, the investment now required is very close to a billion dollars. I think this is an accurate number for the DC-10 and Lockheed 1011. It's almost too much to expect a single company to undertake, especially when that sort of money may be several times the actual worth of the company. I think the technology has to be pushed with a good deal of Federal support. I think the sessions here have been very fruitful and, as you know, Oran, we have been working very closely with you on the joint STOL program, where we look at our part of the business, which is the air traffic control environment – what's needed for certification and safety – and you look at the vehicle side. To elaborate on this, we have a joint program where we share the cost of an airplane – the Buffalo. NASA is putting up half the money and FAA is putting up half the money for the airplane. It will be an integrated test bed, will use the NASA STOLAND system in the airplane, and will operate in a joint flight program. It will give us an integrated approach, not a market demonstration, but at least we can learn something about procedures, how to fly in and out of 2000-foot strips, and aspects of the noise problem. Later when the augmenter wing comes off the line, we will operate with NASA on that one too. It's a very good joint program. I might also note that Langley is directly tied into our air traffic control simulation facilities at Atlantic City – real time. So we can introduce the NASA STOL simulations into our air traffic control simulations at NAFEC on a joint basis.

Moderator:

What about the phase of introducing the nonaeronautical community, you might say, to the new machine, like the passengers and the people who live around the airports? How do we do that?

Gus Lundquist:

I think this will have to be done in time. There is no question that we have been very unsuccessful, as Lou will tell you later on, in trying to introduce the STOL service or demonstrations in the Northeast corridor. One reason for this is the great public opposition to any close-in airport or to any close-in aircraft operation.

Noise and pollution are without doubt very serious problems that we all face in aviation in introducing any new service.

Having been unsuccessful in introducing an operation in the Northeast, we looked elsewhere and just 2 weeks ago the first STOL operation, now supporting Disney World, started. But this is only a very basic approach using Twin Otter aircraft, this service being provided from Orlando and Tampa-St. Petersburg. In time it should be expanded to a statewide STOL network including Jacksonville-Miami Beach. The FAA, in this particular instance, helped the Florida Department of Transportation in their planning. We also assisted Disney World in their design of the airport and of their terminal building which should be completed very shortly. This will give us at least a near simulation of operating in a city-center environment. An STOL strip is right next to the entrance to Disney World. You can walk off the airplane and enter the gate. There are a lot of people around and I think if it proves successful – and I'm sure it will, even with the Twin Otter – that this operation will give us the first leg to perhaps expanding into some other areas in the U.S.

I'm now looking at, perhaps, a second try at the Northeast corridor. We've been talking about getting from the Department of Defense the use of the Anacostia Airport as one terminal – we need one in Philadelphia, we need one in New York or New Jersey, and we need one in Boston. We have a second effort operating at the Houston International Airport, again using Twin Otters from the Clear Lake Facility. We marked off STOL strips at the International Airport. What we are getting there is some operational experience, perhaps not using the ideal aircraft, but it gives us what we need in planning for what will become a commercially viable STOL system – hopefully introduced somewhere around the mid to late seventies when larger aircraft, hopefully the right aircraft, become available.

Bob Collins:

One thing I haven't heard you say, one word you have not used in all your talk, is "airlines." You haven't said one word about the user of the airplane when you're talking about these STOL systems.

Gus Lundquist:

Well, that's right. Of course, I see Scott Crossfield over there – he and I have had many discussions on STOL and I know he was a great pusher for the Disney World operation. At the present time, as you know, the Disney World operation is what I would call a feeder operation, with Shawnee and Executive running their Twin Otters. In time they will get some interline agreements with the major trunk lines serving Florida. This evolution of STOL is one way of introducing such service; however, I would have expected the major airlines to have taken the lead and worked with the airframe manufacturers in producing the right airplane for the job.

Bob Collins:

Maybe that is because we didn't see a market.

Gus Lundquist:

That's right. A critical part of our STOL effort is market analysis, and we are doing it. I think the Disney World operation may provide us with some data that we can apply and interest Eastern, United, and other airlines into providing that kind of service.

Moderator:

Dick, I think, has a point to make here.

Dick Black:

Right. I would like to comment on this too, because I think that these points actually come together in a risk situation. Speaking from a manufacturer's viewpoint, I think if we had the ideal STOL airplane parked out on our flight ramp today, we would be a long way from a commercial success. We have got to have entire system implementation as you mentioned, and this involves not only the STOL ports but also the air traffic control systems and the building of the market. Now this is such a big risk in business terms, in terms of the amount of money required and the uncertainty of the recovery of those funds, that it doesn't seem to me that there is any possibility of the STOL system coming into being in a viable way without total Federal Government support. The Federal Government is the only party who has resources which are broad enough to manage all the diverse parts of the STOL system; so I think the kinds of cooperation that you are mentioning, Gus, and that NASA is sponsoring are first steps, but I think it is beyond the reach of a reasonable business risk for any manufacturer, or any airline as far as that goes, to leap off the bridge into the STOL business.

Gus Lundquist:

You are absolutely correct. It's going to take a coordinated effort. I look forward to the NASA experimental aircraft program to at least provide the type of aircraft that industry can produce commercially. But we are not the only ones pushing STOL. The Canadians will start spending about $20 million in the next year and a half on a market demonstration between Ottawa and Montreal, again using Twin Otters. Hopefully, in time, DeHavilland of Canada will produce their DHC 7 which will carry 48 people and make it a more attractive vehicle for commercial operation. But, in the meantime, you can gain a great deal of experience even with the smaller aircraft. You can learn what the air traffic control system requirements are, and how to fit a STOL into our total network. After all, to make it an economic proposition you have almost got to provide an unhindered departure, direct flight to destination, no holding, and straight-in landing; otherwise, you are not going to gain very much with STOL operation. There are many problems that have to be faced, and hopefully I think the various projects that NASA and FAA have undertaken will lead to solutions to these problems. I think the joint effort is going a long way toward establishing the market realities, and perhaps getting the industry, both the airlines and the aerospace manufacturers, on board in time to come up with a system. There is no question but STOL has to come – it is one of our main approaches in relieving terminal congestion.

Moderator:

Could I pick up on this thought and ask Lou Achitoff a question concerning congestion? Some say that congestion at major air terminals could be relieved if we increased the number of international and intercontinental terminals and routes. This approach implies with it a need for efficient transports smaller than the jumbo jets which operate from the more concentrated centers. The theory is, in other words, that the big airplanes are better if you have more passengers using the major centers; but another approach might be to use more intercontinental or transcontinental airports with smaller airplanes carrying passengers from more dispersed starting points. What is your view on the possibility of this approach for relieving congestion as opposed to the trend toward more large airplanes from fewer terminals?

Lou Achitoff:

Well, I suppose it's a matter of locating these facilities where they meet the demands of the people who want to travel. They should be located near traffic generating centers; and this brings us into the whole question of locating short-haul facilities for STOL or V/STOL in locations where people will find them beneficial. Everyone wants to locate the STOL facility in an urban area. Gus just briefly touched on the problems of doing this.

Well, as the people who have to provide the facilities for this type of transportation, we airport operators are faced with the problem of determining which vehicle we should plan for. We heard some excellent presentations today by advocates of STOL, VTOL, and rotary wing. Every one claimed that with advanced technology one should be able to produce a machine of that particular type to carry a large number of passengers and to do a particular job. Furthermore, they all contended that they can do the same job. We are certainly in favor of these parallel research efforts continuing, but at some point we must zero-in and select the vehicle, simply because we have a problem of lead time.

If you want to establish a STOL port or a VTOL port in an urban area, you probably need about 6 or 7 years of advance planning. You must acquire land, and this immediately brings you into conflict with local communities and the local political jurisdictions interested in zoning and environmental problems. You then have to think in terms of developing access to the site – a very serious problem. The site then is evaluated in terms of obstruction problems, which will vary with the type of vehicle. You need to look at Navaids, the proximity to other airports, noise footprint, passenger demand, and so on. We think it takes about 6 or 7 years to do a thorough study and finally complete the construction.

If you need this amount of lead time, it means that in order to have a system in operation by 1980, you need answers in 1973 or 1974. Everyone speaks about evolutionary processes, but what does evolution mean in this case? Can we evolve from STOL to V/STOL? From what we have heard here, they are two distinctly different animals and, therefore, you can't evolve from one to the other. If we decide to go the STOL route and spend a billion dollars on a STOL system, including the development of engines and airframes and then production, it can't be written off in 5 years. However, references have been made to STOL in 1980 and V/STOL in 1985, or STOL in 1985 and V/STOL in 1990. What we need of NASA, Oran, in the next several years, is a look at the entire system and technological state of the art; and finally, guidance as to the direction in which to go.

Moderator:

Thank you. We will come back to that question and the many implications that go with it.

Let me address this question to Cal Wilson.

The CARD study report indicates that in 1969 about 149 million passengers enplaned on commercial aircraft for all classes of trips, including interurban, long-haul domestic, and international, while some 200 million people enplaned in general aviation aircraft for trips of varying length and for different reasons. In view of this large traffic in the general aviation area and the attractiveness of independent uses for air transportation, if one assumes that people who got attracted to automobiles have the same motivation for attrac-

tion to air transportation, what emphasis should be given to research and development for general aviation?

Cal Wilson:

Well, Oran, I think right now that the main emphasis has to be in the area of safety. As you know, the airlines have an excellent safety record. The safety record of general aviation has not been as successful, and this is an area where I think we must improve in order to keep our lead in the market. To give you an example of our position in this industry – of course I am outnumbered here five to one – I would like for you to know that 95 percent of the aviation fleet are general aviation airplanes – 95 percent. Fifty percent of passenger miles are flown in general aviation airplanes. So we should demand some real effort in improving our airplanes. And when we talk of general aviation airplanes, we are not talking about Jet Star, altogether; we are talking about Cessna 150's and Cessna 192's and Cherokee Arrows, and so forth.

Now to give you an idea of the current state of the art of our avionics, we have currently in the lightest airplanes – in the single-engine airplanes – flight directors, dual avionics 360 channel, digital ADF's, transponders, DME, radio altimeters, course line computers, glide slope, marker beacons; and in our twin-engine airplanes, radar, pressurization, and air conditioning. Now we do this in a much smaller package with a useful load 30 percent of gross weight. So we have done some pretty good successful designs in the light airplane industry. With respect to NASA's contributions to general aviation, they have recently done work on production airplanes, somewhat after the fact. And in Dr. Fletcher's address the other night at the banquet, no mention was made of general aviation airplanes. We in general aviation feel that noise and pollution certainly have an important place in research and development. However, safety is all important to us.

Now, in what areas of research in light plane aviation do we feel NASA can assist us? Well, let's start with some aerodynamic improvements:

- Airfoils, flaps, and simple systems of high-lift devices
- To improve the inherent stability without having a lot of black boxes to solve the problem
- Information on tail volume and hinge characteristics; augmentation devices, mechanical and electric; and the effect of such things as twist and dihedral, and such things that haven't been worked on for years and years and years
- In the area of structures, fatigue is an important factor now in general aviation because of the high utilization of the airplane
- Work should be done by NASA on scatter factors, methods, materials, and construction

- In the area of structures, flutter and aeroelasticity have become important factors because we are getting into fairly high speeds for our types of airplanes; 350 or 400 mph are speeds which require more sophisticated flutter approaches
- And we should have developed equations of motion and computer programs to satisfy these requirements
- In the area of power plants, we need information on altitude characteristics of engines for cooling, operations, icing, and so forth

So we have here somewhat a contrast of the environmentalist and the need for safety. NASA can help us in this area.

Bob Collins:

I like that question, Cal. Is your safety problem due to airframe, electrical failures, and that sort of thing, or is it human failure?

Cal Wilson:

For the most part, human failures; however, we can't ignore the fact of the airplane-pilot relationship. If we could make it much more simple to fly, I feel we would have less problems. Now let me say one other thing. There are two areas that seem to be very popular right now – the environmentalist and consumerism. Due to the fact that we sell airplanes to the public, we are directly involved in consumerism, and product liability has become an increasingly important part of our work. If we don't soon find ways to improve the safety of our airplanes, we are going to be putting placards on the airplanes which say "Flying airplanes may be hazardous to your health." So what I would like to say is, we would like to have the airlines move over a little bit and let general aviation have a little room.

Gus Lundquist:

Cal, could I make one comment? You opened by saying you represented general aviation interests and you were outnumbered five to one. Let me say that FAA – I'm representing the FAA – is dedicated to providing an air traffic control system of service to all users, including general aviation. So $4\frac{1}{2}$ to 1 – you have an ally here.

Moderator:

That's really good, Cal. Now to go on, to the guy who's most relaxed because he doesn't see how I can get to him with the next question – Bill Sens. So I'm going to raise

a question for you, Bill. The engine-airframe integration question – always a major factor from the very beginning of powered flight – is increasingly important on propulsive lift systems of the kind required by STOL vehicles. Do you foresee different roles and relationships as required between manufacturers of aircraft and engines to account for these interacting effects of performance, noise, and economics for operation of the new class of planes?

Bill Sens:

What you say about the importance of engine-airframe integration is very true, Oran. It will be even more important for the STOL, the SST, and the transonic transport aircraft, as the general problem of properly integrating the propulsion system, airframe, and operational systems is much more complex. I think what this means is that we propulsion people, the airframe people, you at NASA, and the other Government agencies are going to have to work together much more closely, particularly in the initial planning phases of these programs, in planning and in working out the technology. For instance, the problems presented by the STOL aircraft in terms of the combined effects of the engine, the lift, and the aerodynamics are compounded by the very stringent noise requirements and present a real challenge. I think that one of the things that is probably most important at this time is for us collectively – industry, NASA, and other Government agencies – to work out the best way of utilizing our respective talents to address this problem and to try and figure out what's the best approach to take to obtain a viable STOL system. This is a rather fundamental question that we haven't answered yet.

Bob Collins:

You left out the airlines, again.

Bill Sens:

Excuse me, Bob. The airlines – and very properly brought up – the airlines are participating in the advanced technology transport program as well as in the other combined efforts that are going on and they are a very key part of the problem.

Bob Collins:

Why does everyone keep forgetting?

(Laughter)

Moderator:

Can we go on to the airlines and come back to you, Bill? I sure don't want to be the one who leaves out the airlines. I think this question does deserve a lot of thoughtful

attention, and I know it is in the minds of a lot of people in this audience because it is obvious that a team effort is necessary for the system effort required. I guess, Bob, I'd like to know your views on the predominant pressures you expect in the seventies and eighties for employing new technologies – will it really be the nonuser who sets the course, will it be the vacation or business traveler, will it be cargo and freight, or what? And while you are at it, how do you foresee the foreign effects of competition for uses of aviation on your whole business? Now you just take all of that and do whatever you want to with it.

Bob Collins:

You have a formidable list of questions over there – a nice sheaf of papers. I wish I had a nice sheaf of answers over here to talk about. Well, first of all, there is no question but what the environmental aspects of things are going to be predominant in the seventies. I won't try to comment on whether all these pressures are valid or not, but they are there, certainly, as a fact of life. As far as something like the advanced technology transport is concerned, we feel the pressure of NASA for a Mach 0.98 airplane or 0.95 airplane as being somewhat unrealistic from our viewpoint of things. It could turn into something like a DC-7, that has a very marginal speed advantage that really doesn't sell, given the additional increment of operating cost. I think that the supersonic transport, on the other hand, does have enough speed advantage to where you can really say that speed does and will sell, if it can come down the pike. I was very happy to hear a paper this morning and see that we really have some progress being made toward a second-generation SST, and I certainly hope we can see that get off the ground in the near future, because it is a part of the future. But getting back to the advanced technology transport, the potential weight savings – for example, composite structures – additional L/D that can be gained from a supercritical wing, and things like this, seem to me to be available perhaps to create a second generation of subsonic airplanes that are much more economical than our present generation. And if they are going to sell them to us, I think that's what's going to do it – the economics, not the speed. Now what other part of the question do you have?

Moderator:

Well, I think you answered part of it, concerning what is going to be the driver for your requirements. Let me repeat one question I threw in there – about the people you serve. Obviously, the environmentalists in many cases are the nonusers, so we have already covered them. Who is using airlines these days, and what do you see in the way of change, if any, for cargo or other things; that is, what segment of people are using the airlines or how is that picture changing and what future do you see for cargo and other applications than hauling people?

Bob Collins:

True, the business has traditionally been a business of business travel, but we see that changing now and we don't see ourselves as much in competition with other forms of transportation. So we aren't really competing any more with the railroads or the buses. Maybe if we get into STOL or things like that, we will again. We are really in a different kind of business, other than transportation business now. As we see more and more pleasure travelers, you could call our business turning into the recreation business. We are competing with boat manufacturers, resort operators, and things like that, for people's leisure time.

Moderator:

Have you got a percentage?

Bob Collins:

Well, I think it's turned around recently to where now pleasure travel represents more than 50 percent of RPM's [revenue passenger miles] and this trend is still in the direction of increase in pleasure travel relative to the total. Another way of looking at it is that we are in the communications business. We will be competing, I think, with things like visaphones and the telephone company. This puts a whole new aspect on our business. We are no longer, you might say, in a market where we have complete dominance, as we were when we were in the transportation business. And I think that's an interesting way to view the changing aspects of the airline structure. Another thing is cargo, and I'm sorry, I'm not an expert in cargo by any means but I can tell you this, cargo has been touted as being one of the great future growth potentials but we see no other growth in cargo except ton-miles, and we haven't seen any growth in profit from all cargo operations. I think I can sum it up that way. It has been rather disappointing from that aspect. I don't think things like the C-5 or cargo version of the 747 offer much potential in the near future to improve that situation because of the great expenditure in ground equipment – ground facilities needed to handle those kinds of airplanes. Maybe we can do it in the future.

Moderator:

Lou, did we torque your gyro a little bit there?

Lou Achitoff:

Well, Bob did mention the environment and I suspect that sooner or later we will get down to a discussion of the environment and the involvement of the airport operators in the environmental problem. The other night we heard Dr. Fletcher speak about the

importance of the noise problem and the environmental problem. Everyone now recognizes that this is one of our most serious problems and I'm glad that Bob did mention it. It's pointed up in the CARD study and I can't think of any prominent individual who is associated with aviation who hasn't stated that we have a serious environmental problem that we must solve. Unfortunately, although the title of this conference is Vehicle Technology for the Seventies and Beyond, most of what I've heard here is focused on the beyond – very little on the seventies. I think we ought to talk about the seventies because we have to get through the seventies in order to get to the beyond. All of which reminds me of Mark Twain's comment about the weather, and I'd like to apply that to noise – everyone talks about noise, but no one does anything about it. All the solutions that we saw today were advanced technology solutions for the 1980's. We must do something about the problems of the 1970's.

And what's our problem in the airport business? Well, first of all, we can't build new airports even though our forecasts show that by 1980 we'll have to accommodate about twice the number of passengers we do today. It's true you can put them in larger aircraft, which will flatten the curve of increasing aircraft movements, but ultimately we have to face the fact that the movement curve is going to go up, and we'll have to expand the airport system.

We have been trying to build new airports and expand existing airports in the New York area since the late 1950's and we have been unsuccessful because of the opposition of the community. Essentially, it's the noise problem. This is true not only in New York. Let's look at: Los Angeles – they thought they would be able to build an airport of the future in Palmdale, out in the boondocks, and at this moment they are not able to do anything about it because of environmental problems; the Miami experience in the Everglades – I think you are all familiar with it; and London's airport study – despite the reasoned recommendations of a commission that devoted 2 years to it, the U.K. has decided that the only permissible location is Foulness, which is about 60 miles from London and practically inaccessible.

We can go on and on, but it's clear that the noise problem is going to seriously compromise all that nice technology of area-ruled airplanes and supercritical wings if they can't operate from anywhere. There are curfews at many major airports now, and there are further threats of curfews in the New York area. I believe someone at some point today simply assumed that there would be one when he questioned the utility of the Mach 5 airplane. There is restrictive legislation in being and more being planned, so that if you have to comply with such restrictive legislation as planned, for example, in California, the movement rate at Los Angeles airport would have to be cut in half in order to meet it with existing aircraft.

Bob Collins:

You could spend a billion dollars to buy property.

Lou Achitoff:

Now, let me comment on that. We think, Bob, that you can make substantial noise reductions in existing aircraft. I know it can be done; yet it was not a subject of discussion at this particular conference meeting, Oran. We heard some tapes that were quite impressive; we heard the 707/DC-8 levels, and we heard FAR 36 levels, and we heard quiet-engine levels. You can bring noise levels of the 707 and DC-8 down to FAR 36, particularly in the approach, which is one of our biggest problems. What I'm saying is that if it isn't done, we are not going to see much new technology, which in turn will mean that an aerospace industry which is dependent upon new technology may not be in business. We have got to get away from what I would characterize obsessive preoccupation with DOC and accept that the true definition of an airplane is a powered flying vehicle which is quiet. It must be part of the basic definition; otherwise, it isn't an airplane. Profit is the difference between revenue and cost; and a noisy, low DOC airplane will not produce revenue.

Gus Lundquist:

Could I add one there, Lou, based on your mentioning that nothing was said about the work on existing fleets. Actually, NASA did a very extensive study effort and flight demonstration of quieting the DC-8 and 707 with the JT3D engine, and the FAA has now continued that work. We have two parallel contracts with Boeing Aircraft to look at acoustical treatment of both the JT3D-engine-equipped aircraft and also the JT8D-equipped aircraft, the DC-9, 727, and 737. The progress on our work at Boeing is very promising, and there is no question in our minds that you can get down to the noise levels on the DC-10 and the Lockheed 1011, which are quite well below the FAR 36 requirements. You can do it at a not prohibitive cost.

Bob Collins:

What's "not prohibitive," Gus?

Gus Lundquist:

Well – by whose standards? Let me put it this way. The original estimates to retrofit the DC-8 and the 707 fleet ran upwards of 500 million to over a billion dollars. I think we are getting down to something considerably lower than that number and it may still be prohibitive as far as the airlines and their present position financially are concerned, but at least you can quiet the present fleet. The other question that you have to

face – if you look at the 707 and DC-8 first-generation jet aircraft, is whether it is really worthwhile to retrofit, since the service life may be quite short for that particular fleet of aircraft. And this is where the economics come into play, the market value of each of these aircraft today is somewhere around $1.6 million. How much can you afford to put into retrofit cost where that is the cost of an aircraft?

Bob Collins:

Depends on how much it costs to replace it.

Gus Lundquist:

You're right, Bob; I agree. Anyway, the work is going on – it's promising.

Lou Achitoff:

Gus, I couldn't be happier listening to all of this, because I am beginning to see some glimmer of hope that perhaps the forthcoming rule that the FAA has been talking about for several years on the retrofitting of the existing fleet of aircraft may come to fruition. You are saying now it appears to be more economical – I think that's just wonderful, because after all there are about 2000 airline aircraft flying around with what we might call current technology and only 10 percent DC-10 and 747. As Bob points out, you don't think of an airplane in terms of the $1.6 million investment you have, but what does it cost to replace it. And when you consider economic conditions today, it doesn't appear to be in the cards that phase-out of four-engine turbofan equipment is something that we can expect in the very near future. We have a problem that we must face right now, and we must show the public and the people who are creating problems for us that there is good faith on the part of the industry and that you are willing to carry noise reduction as far as the state of the art permits.

Bob Collins:

I have to disagree with that, Lou. Your statement implied we have got to take this as far as the state of the art will permit us. And doggone it, somehow or other, we have got to make the public and ourselves aware, I guess, of the value to society of these kinds of changes that we put in for any environmental reasons. We have to relate cost to value somehow. Just because some people happen to live in the vicinity of the airport and complain about noise around the airport doesn't seem to me to be a preemptive reason for saying we have to carry things to the state of the art. I don't know where the value is, but somehow we have to be looking at both sides of this.

Dick Black:

I'd like to stick my two cents worth in here. I think there have been many proposals for reducing noise of aircraft. I think these you can divide very carefully into two groups, those which are cost effective and those which are not cost effective. In addition to that, there are also solutions which aren't even effective from the noise reduction standpoint and it is debatable whether the change would even be noticed by the public. And in some cases these are fairly expensive changes, but among these are things which are cost effective and which are coming to us in the seventies, Lou, and I think this was mentioned by Gus also – the use of the high-bypass-ratio engine on the airplane is a tremendous step forward. It is a greater step than you might realize by looking at the noise levels that are measured, because the noise that comes out of high-bypass ratio is primarily in the higher frequency range which is attenuated in the atmosphere so that if you are a little further away from the airplane, as most people are, than the FAR 36 measuring points, the noise is even remarkably lower – appears to be lower – than with the present or previous generation of aircraft.

The second kind of changes which are cost effective are those associated with operating procedures. Both the FAA and NASA have done a lot of work on steepening glide slope and this seems to be a very cost-effective method of reducing noise because it doesn't handicap the airplane with a lot of additional weight. It doesn't require a lot of heavy and costly equipment, but it does require demonstrations of equivalent safety – we can't adopt any operating procedures which will compromise safety. So this is something that has to be sold. I think this is primarily a matter of timing. We must have reliable guidance equipment in the aircraft or on the ground to provide the pilot and the crew with a secure feeling when they follow a steeper glide slope down. At the same time, there is now the possibility for more accurate control of the aircraft on departure with the area-navigation devices so that thrust reductions can be made at the most appropriate point rather than an arbitrary altitude – there again applying the benefits to the community at a very low or no additional cost to the operation. These are the areas in which we have to concentrate our attention. It is absolutely frivolous to design hardware which cannot be purchased because our friends in the airlines do not have the money; in fact, there isn't that much money in the world.

Moderator:

Thank you, Dick. I would like to reassess what we just heard and give you a chance to think. It seems to me that Lou, from his airport viewpoint, is wringing his hands a bit because he is in between all of you guys and those noise-mad people who are raising Cain. He is saying, "For goodness sake, we want the long-term things you are talking about, but do something before we get it in the neck here and now." And I guess what I heard in reply was that you <u>are</u> doing things; some of those things you wanted to do anyway. For

example, the fan is good both for noise and for other reasons and you are obviously going in that direction; you are also saying that from the airline standpoint you are willing to pursue this exploration of operational changes and all possibilities to relieve the current problems as best you can. The airlines are surely almost as sensitive to this as Lou, because the same people are beating on you – and everybody is sort of lined up in a row here because the bread and butter for all depends on it down the way.

On the other hand, if I can stimulate some thinking, I agree with Lou in the view that we need some rather dramatic emphasis on short-term results. We aren't really satisfying the public very well today, it seems to me, with the plans and the small incremental steps that we seem to be taking. Is there any way you can think of that we can put our efforts together somehow in a more dramatic demonstration of what everybody is doing so that the people will understand it?

Lou Achitoff:

Oran, I think one of the real bugaboos here is the cost of doing these kinds of things. Now, we don't expect the airlines to bear the full brunt of the cost of making their airplanes quieter. Obviously, this would be a financial burden that would be much more than they could assume.

Bob Collins:

Are you going to lower your landing fees, Lou?

Lou Achitoff:

Bob, are you prepared to deal right now?

Bob Collins:

We gotta do some of that before this is over.

Lou Achitoff:

What I am about to say is that I think the traveling public is going to have to pay a substantial part of all of this and I am convinced, based on work that was done for the FAA by the Rohr Corporation, that you can finance the cost of an entire noise retrofit program for all the four-engine turbofans at a nominal increase in the ticket price of 60 cents additional on a $100 fare. The airlines have traditionally opposed increasing fares except when the results of the fare increase accrue directly to them. They are not adverse to asking for fare increases, but they don't like it for this kind of purpose. It isn't "pie in the sky," which is the point I am trying to make.

Bob Collins:

I agree with the philosophy. That is, polluters of any sort should pay for the polluting and certainly the air traveler, I suspect, is the fundamental guy creating the pollution. We just provide the service that allows them to do that. If the airlines are to bear the total cost through increase in fares, then I think that negates the fact that there is a certain value of airline service to the community itself. One way of assuming some of these costs might be to say that it is a shared responsibility. Our landing fees might in fact have to go up, as you passed your cost on to us as you bought property, and we in turn would have to pass that on to the passenger. If you put it all on the airlines' shoulders, the communities bear no burden.

Dick Black:

I think there is another factor that you can't ignore, and that is increased fares may not yield any additional money because the traffic reacts by a reduction when fares are increased. Thus, the amount of increase to yield a given sum of money is difficult to determine. Sixty cents is hardly a stopper on a $100 fare, but the fact is that when you start increasing fares – 6 percent has been done in the last year – there is a noticeable drop in traffic and the total dollars into the airline isn't necessarily increased when the fares go up.

Moderator:

While you are on your feet, Dick, let me ask you a question that sort of changes the subject in order to cover a lot of ground here. With the demise of the U.S. SST program, the good side of that decision, if there is one, is that the options are now open for a complete new look at the future U.S. emphasis. What do you think we should do toward achieving a new position, a national position on the SST? For example, should we reassess the whole basic philosophy of the design with our new technology? After all, the SST we have been working on started back before we knew some of the things that have happened in the last 10 years. Are there new technologies that we want to start with, should we skip the whole blasted thing and go to the hypersonic application, or should we now fall back and try to compete with the Concorde and TU-144, a la 707 versus Comet? Just how do you view that in light of today's situation?

Dick Black:

Well, first of all I really feel that the supersonic transport is the area of intense interest to this country in the future. I think from what I have seen that the first-generation supersonic transports of today are going to be marginal performers, in that the economics of those machines are marginal. Strictly, in light of what's happening to

the international transatlantic fare structure, where fares are under great pressure – currently coming down – and the analysis that I have seen of the fares of the supersonic transport of this generation, one is bound to reach the conclusion that we are going to pay a substantial premium for supersonic travel. This limits the market, because the number of people who will fly in these aircraft at a premium fare determines the total number of aircraft which will be purchased. This influences the selling price of the aircraft, which is necessarily high. I think there is definitely an opening for this country with regard to what I will call an advanced supersonic transport. Also, I think that the thought of leaping to the hypersonic transport and bypassing the supersonic transport is rather highly adventurous. I think we need the technology base of the supersonic transport to build on before we go forward to the hypersonic airplane, because I frankly think that the work being done on hypersonic vehicles today is far ahead of the industry as we see it now. With costs quoted in the last paper of the conference as three or four times the current levels of cost for range performance at 6000 miles, look at the actual revenue passenger miles traveled at that range and imagine what the fare might be. The market for those machines looks like you could count it on your fingers and toes – the total number that would take care of the world demand in the year 2000. Well, it is not a very attractive market at the moment. Then it leads us back to the supersonic transport as being certainly a step that we should take in the interim.

I think every area of the technology that was so well aired during the Congressional hearings we had last spring, and ending in the demise of the aircraft, should be investigated. And a lot of the things that were aired at that time turned out to be, at least in my opinion, superficial and poorly substantiated claims or counterclaims on both sides. I think all that should be very carefully reviewed. I think we should examine our position as to what Mach number we are going to cruise at, because that has a big effect on the initial cost of the vehicle. I think the other factor is the range of the supersonic transport. You're just starting to get into the area of payoff at about 3500-mile range. In other words, you are just making the transatlantic flight and there are a number of city pairs just beyond that which are a great attraction to the operator. An optimum range would be on the order of 4000 miles in order to really capitalize on the timesaving this machine is going to offer. Therefore, we need to increase the range, we need to examine the cost of building it, we need to look at the sonic boom as to whether we could handle that by getting the aircraft to a higher elevation or doing the job with a slightly smaller vehicle. There are a tremendous number of technology areas to be explored for the supersonic transport. And I think there is a real market opportunity, because the initial machines appear to me, at least, to be marginal performers.

Moderator:

Thank you very much. I have one question, Lou, I thought you might address since you live downtown and you have seen helicopters used in your area. What do you think are the most important things to do to help develop helicopters for transport application?

Lou Achitoff:

As others pointed out, I suppose the primary problems with rotary wing transportation today are the economics and the relatively uncomfortable passenger levels of vibrations. Passenger riding qualities must be improved and a way found through new technology to materially reduce the cost of operation and maintenance.

Moderator:

Bill, I had another question for you that is more engineering oriented. How are companies like yours, which really bear a rather major burden here for the noise problem, getting involved? In other words, the engine is a rather large contributor to our present dilemma.

Bob Collins:

Why don't you fix that?

Moderator:

That's the whole point. How are you coping with the problem of teaching engineers who have been trained by the fight over the years for increased performance and efficiency, and so on, to cope with the disciplines of acoustics and physics of noise which they may or may not have been exposed to in great depth?

Bill Sens:

I am sure, Oran, that you are well aware that the art of acoustics is a world in its own and, of course, we like other people have developed groups of acousticians to work that side of the problem. But the problem is much bigger than just that of the acoustical expert. It is really bringing to bear all of the technologies on the noise problem. I would like to deal a little with that if I may, since I guess we are the culprit in generating the noise in the first place. As Dick mentioned earlier, the high-bypass-ratio engines which are now in operation represent a real step forward in the state of the art of noise, producing much lower and acceptable noise levels than previous turbofans. However, the objectives of the CARD study, the NASA objectives as presented here, and the airport operators and the airlines with their problems with the local environment, are to reduce noise levels significantly below what we can do today. There is the NASA Quiet Engine

Program. There have been fan test programs done under FAA, NASA, and industry sponsorship, going back over a period of years, to try to determine how we can design the engines to lower the fan-generated noise; and with the high-bypass-ratio engine the fan-generated noise has become the predominant noise. Based on this work, plus extensive work on acoustical treatment, it looks like the approach noise, which is most difficult to meet for a conventional take-off and landing aircraft, can be reduced to the FAR 36 to maybe FAR 36 minus 5 range without what might be considered an unacceptable economic penalty. Although what is acceptable and what isn't is certainly open to a lot of debate.

Now, the real question is how do we achieve the objectives that have been set forth here of bettering these noise levels by roughly 10 PNdB per decade. In the presentations that we heard yesterday and the day before, it was assumed that somehow or other we were going to figure out how to reduce the noise generated by the fan by 5 PNdB below what we know how to do right now; in addition, we were going to achieve acoustical treatment that will be significantly more effective than what we have in hand today. And these are difficult achievements because the industry and NASA have been working these technology areas for a number of years and we have sort of taken the cream off the top of the milk. Further progress on noise reduction is going to take a lot of detailed hard work on the fundamentals of the fan noise generation process itself, on how the fan noise relates to the various design variables that we have under our control, and also on improved means of acoustical treatment. The attenuation to date due to acoustical treatment has been relatively effective because they were tuned to rather narrow frequency bands, where the noise levels were the highest, and knocked down those peaks. Achieving additional attenuation will require reducing the noise level over a broad band of frequencies, which is a much more difficult problem than tuning the treatment to take care of one particular frequency. The point I want to make is that it is most important for the industry and NASA to work out the most fruitful approaches to work on the fundamentals of noise generation and improved noise attenuation, and get started with a well funded and continuous program in this area. This is really the only way that lower propulsion-system noise levels are going to be achieved in the future without sacrifice in economy.

Bob Collins:

It just occurred to me there is one other way you could do it, and that is to go back to airplanes like the Electra and the Britannia. These are very quiet airplanes and if we had a national policy that said that airplanes are too noisy, and that what is in the best interest of the country is to have very very low noise levels, and that we can't afford to do that with turbojet engines but we can do it with turboprops and sacrifice the speed – maybe we could accept something like this as a national policy. From the airlines' standpoint that wouldn't be too bad. We would all be competing on an equal basis. The

only people that it would hurt would be the traveling public. I just wondered if we had thought of that kind of solution. There are other ways to do it.

Moderator:

Well, gents, this has been a provocative session. We do not have time to allow the discussion to continue because I promised to get many of you to the airport for that 12:50 flight. So, in the usual TV tradition whereby a commercial comes along and interrupts the show just when it gets good, I guess we are going to be forced to terminate this discussion at this time. I want to thank you all very much for your candid comments. I think they are helpful and I appreciate your taking the time to share them with us all.

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